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Recognising the ageing face: the role of age in face processing

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Abstract. The effects of age-induced changes on face recognition were investigated as a means of exploring the role of age in the encoding of new facial memories. The ability of participants to recognise each of six previously learnt faces was tested with versions which were either identical to the learnt faces, the same age (but different in pose and expression), or younger or older in age. Participants were able to cope well with facial changes induced by ageing: their performance with older, but not younger, versions was comparable to that with faces which differed only in pose and expression. Since the large majority of different age versions were recognised successfully, it can be concluded that the process of recognition does not require an exact match in age characteristics between the stored representation of a face and the face currently in view. As the age-related changes explored here were those that occur during the period of growth, this in turn implies that the underlying structural physical properties of the face are (in addition to pose and facial expression) invariant to a certain extent.

1 Introduction

Although face processing has been researched intensively during the past twenty years, one aspect has been largely ignored, the perception of age. This is a major omission in our understanding of the processes underlying face perception, for two reasons. First, any theory of face recognition is incomplete without an understanding of age perception, given the importance of age as a facial characteristic. For example, Shepherd et al (1981) identified age, face shape, and hair as the three major dimensions which seem to account for all perceived variation between faces. More recently, Johnston et al (1997b) used multidimensional-scaling techniques to identify the possible dimensions used to encode faces, and came to a similar conclusion. Age information is therefore likely to be involved in the initial encoding of faces. If so, an understanding of how age is processed will be crucial to a complete understanding of how faces are encoded and stored for recognition purposes.

Second, exactly how the visual system manages to recognise faces despite age-induced changes is a special case of a more general problem which besets any face-recognition system: how to establish a match between a face that is seen and an internal stored representation of that face, despite all the accidental changes (in lighting, pose, expression, etc) which occur between one encounter and the next. We can gain insight into the nature of the facial information used for face recognition by identifying factors that do or do not affect the recognition process. There is now a considerable amount of research examining the tolerance (or otherwise) of the recognition system to various 'perturbations' of the input face. Thus, it is now known that face recognition is markedly impaired if the face is inverted (eg Yin 1969) or presented in photographic negative (Bruce and Langton 1994; Johnston et al 1992; Kemp et al 1996); that recognition performance is either unaffected (or even enhanced) by 'caricature' [exaggerations of the deviations of an individual face from the 'average' face (Benson and Perrett 1991; Rhodes et al 1987; also see Rhodes 1994]; that recognition performance is reduced,

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but still well above chance, if the face's pose and/or expression are changed between presentation and test (Bruce 1982); and that recognition is largely unaffected by the elimination of colour, three-dimensional, and motion information (Bruce 1988).

Taken together, the responses of the face-recognition system to these perturbations tell us that the processes involved in recognition rely heavily on the configurational properties of the upright face; that these may be represented in memory in terms of deviations from some prototypical or 'average' face; and that shape-from-shading information is also important for recognition. The changes wrought by age upon a face can be seen in this light: they represent perturbations of the facial input that, ideally, would need to be disregarded if successful recognition is to be achieved. The extent to which age changes in a face *can* be disregarded in practice may tell us something about the nature of the processes underlying face recognition in general.

It is proposed that the ageing face can be used as a tool to gain insight into this issue. Suppose we have two versions of the same face which differ in age. One of these is learnt (and therefore will be represented within memory), and then recognition is tested with the other age version. Recognition performance under these conditions can be taken as a measure of the importance of the facial information that has changed. The extent to which age-related changes can be ignored (so that there is successful recognition of the individual) or not (so that the individual is not recognised) will give an indication of the role of information about age within a new facial representation. If age changes in a face impair recognition of that face, it implies that age information is an intrinsic part of a facial representation. Conversely, if age changes leave recognition essentially unaffected, it suggests that facial representations either do not include age information or that processes exist to take account of age changes in a face, perhaps by 'transforming' the representation.

The main aim of the present experiment was to obtain data on if and how the visual system can cope with recognising faces that have age-related changes in shape[(1)] since the last encounter. Subjects were presented with six premature faces, which they first described verbally and then learnt to recognise. Recognition performance was tested with versions of these faces which were either identical to the original faces or varying in pose, expression, and age. One concern in this study was to see if a subject's initial spontaneous verbal description of a face was related in any way to their subsequent recognition performance. In particular, are subjects who use age-related terms in their descriptions more or less affected by subsequent age changes in a face than subjects who do not spontaneously use such terms? The primary aim of this experiment, however, was to try to find out to what extent face recognition is affected by age-related changes in a face.

Since in previous studies (eg Bruce 1982) it has been found that recognition performance is impaired by changes in pose and expression, it was predicted that the best performance in our experiment would be for the control condition, where exactly the same

[(1)] While we use the term 'ageing' to refer to those changes that occur from birth and continue throughout life, the faces used in the present study cover the younger age range (up to age 21 years), and are therefore specifically related to the period of growth. While many complex morphological changes characterise growth [for example, the size and shape of the individual features and the spatial interrelationship of the features (see Enlow 1982)], the most dramatic changes are those that influence the underlying shape of the head and face. The shape of the face is considered particularly relevant to the present study for two reasons. First, many studies have demonstrated that individuals are extremely sensitive to the changing shape of the head during growth and suggest that this is the primary perceptual cue to age (see Mark et al 1988 for a review). From the perspective of individual recognition, Bruce and Young (1986) suggest that different types of information can be derived from a face. They use the term 'structural encoding' to describe the process by which an abstract description that is independent of the more transitory changes of view and expression is derived that is sufficient for recognition. Thus, it is assumed that the abstract description after the process of structural encoding includes shape-based information which remains invariant of transitory changes that leave the structure intact.

face was seen at presentation and test. If recognition performance is determined simply by the number of differences between the faces at presentation and test, then one might expect the next best level of performance to be obtained from subjects whose task was to recognise the same age face but with different pose and expression. The poorest recognition performance would be expected from subjects who saw faces that not only differed in pose and expression, but which were also either younger or older than the learnt face.

According to the recognition performance for faces of different ages from those seen originally, it may be possible to evaluate some of the possible ways in which age information might be related to facial representation. For example, one possibility is that facial representations do not contain information about age: the incoming image might give rise to a unique and fully age-invariant representation, with all of the burden of recognition placed on the encoding stage of the recognition process. Recognition would involve matching this age-invariant representation to stored representations of faces. This conception of the relationship between age and face recognition would lead to certain predictions about face-recognition performance with faces of varying ages. The processing of all faces would involve initially age transforming them to some 'ageless' representation. Given that this task would be performed independently of the faces in question, one would expect no difference in recognition (number of correct identifications and reaction times). In other words, the time taken to recognise a face would depend upon the time taken to age transform it, which would be equivalent for all experimental conditions.

An alternative explanation is that information about age might be an inherent aspect of a facial memory. For example, the age characteristics at the time of encoding might be stored within the representation of a face. If the physical properties at one particular point in time are incorporated within a facial memory, then an extreme version of this view would predict that the physical changes induced by ageing would render a face unrecognisable. A less extreme version of this idea is that of Ellis (1988), who suggested that there may be multiple representations for each face within memory, each representing a different age. From this point of view, recognition of younger or older versions of faces in the present experiment would pose problems for the processes underlying recognition, because different-aged versions of the faces in memory would not exist.

Yet another possibility is that a face is encoded together with information about its age in a fairly general sense, for example, 'younger child', 'older child', etc. This explanation would lead us to predict that recognition would be possible up to a certain point, ie as long as the age of the presented face did not fall outside of the boundaries of the broad age category to which the original face belonged. Outside this range, recognition would fail.

2 Method

2.1 *Subjects*

Eighty subjects aged between 18 and 40 years of age took part. There were four conditions, with ten male and ten female subjects per condition.

2.2 *Design*

A between-subjects design was used. All subjects initially learnt the same six faces, and were then randomly allocated to one of four recognition conditions: 'younger', 'older', 'same age', or 'same image' (for definitions of the conditions, see below).

There were three dependent variables. The first consisted of the verbal descriptions that were given by subjects for the six faces that were learnt. Two measures of recognition performance were taken, recognition decision (either correct or incorrect) and reaction time taken to make that decision.

2.3 *Apparatus and materials*

Four full-faced photographs were obtained for each of six individuals. One photograph showed a person at a younger age; this would be used as the stimulus material for the 'younger' condition. Two photographs showed the person at an intermediate age (ie younger than at present, but not as young as in the 'younger' photograph). These differed in pose and expression. The fourth photograph showed the person at his or her current age.

These photographs were scanned into Adobe Photoshop image-editing software on a Power Macintosh 7100/66, by means of a Macintosh OneScanner set for 256 grey levels and 150 dots inch^{-1}. All background detail was removed. An example of the different versions can be seen in figure 1. The faces were displayed on the same computer, by means of a program written in Hypercard software.

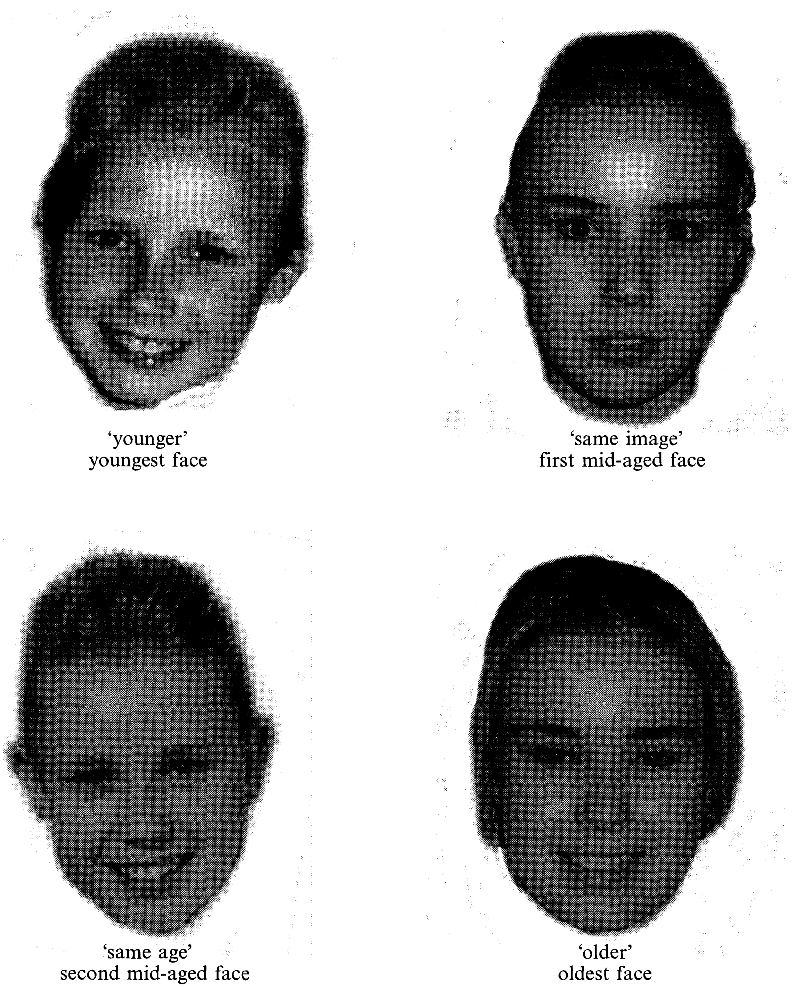

Figure 1. Example of the recognition versions.

2.3.1 *Stimulus faces.* Six sets of facial images (three male and three female) were used. As mentioned previously, each set consisted of four photographs of the same individual taken at three different ages. For each set, the chronological ages of the 'younger' and 'older' versions were chosen so that the age difference between the younger version and the mid-aged versions was equivalent to the age difference between the mid-aged versions and the older version. (The actual chronological ages of the faces used can be seen in table 1.) The labels given to the four versions are an indication of the age relationship between the faces that were learnt and the recognition condition that they would be used in. Thus there were four conditions:

(a) 'younger' recognition condition—at test, subjects were presented with younger-aged versions of the learnt faces;

(b) 'older' condition—at test, subjects saw older-aged versions of the learnt faces;

(c) 'same-image' condition—at test, subjects saw faces that were identical in every respect to those that had been learnt;

(d) 'same-age' condition—the faces at test were the same age as those that had been learnt, but differed from them in pose and expression.

Table 1. Actual chronological age (in years) of target faces.

		Younger face	Mid-age face(s)	Older face
Male	14–21 years	14	17	21
Female	9–17 years	9	13	17
Male	4–11 years	4	7	11
Female	2–7 years	2	4	7
Male	2–8 years	2	5	8
Female	2–6 years	2	4	6

2.3.2 *Distractor faces.* Eighteen distractor faces were used for each experimental condition. These were chosen to match the original faces in age, gender, lighting direction, and general photographic quality.

2.4 *Procedure*

Subjects were trained and tested one at a time. Each subject was initially familiarised with the experimental program and given an overview of the kind of responses that they would be expected to make. Subjects were told they would perform two tasks. The first would be to describe each of six faces in their own words (if a prompt was required, they were told to use "whatever came to mind"), and then learn its name. The second task was described as a "recognition task". At no time during this experiment were the terms "age" or "ageing" explicitly used.

2.4.1 *The learning procedure.* Subjects were presented with the six faces in a random order, one face at a time. Each face was displayed for a period of 5 s. The subject was then prompted to describe it. After this description was obtained, the subject was told the face's name. This procedure was repeated for all six faces. When all faces had been described, they were presented again in a random order. Each face was shown for a period of 2 s, and then the subject was prompted for its name. Feedback was given as to whether the response was correct or not. If the response was incorrect, the correct name was repeated. All faces were shown in a random order on two more occasions. Thus all faces were viewed in total for 11 s (the original viewing of 5 s, plus three additional 2 s presentations). This time period was found to be adequate for all but two of the subjects to correctly name all the faces.

After completing the learning phase, all subjects participated in a training session so that they could become familiar with the procedure of the recognition phase. They were allowed to continue with the training until they were confident about which keys to press and the general method. In general, this only took about 2 min.

2.4.2 *Recognition-task procedure.* Subjects were then randomly allocated to one of the four recognition conditions. They were presented with twenty-four faces in random order. Six of these faces were either younger, older, the same age, or exactly the same photographic images that had been learnt previously. It was stressed to the subjects that their task was to decide whether or not each face was an image of "the same person" as one of the previously learnt faces. It was emphasised that this meant that they were not necessarily being asked to identify the particular photograph itself, but the person that it depicted. They were asked to make each judgment as quickly and as accurately as possible.

3 Results

From each subject, a description was obtained for each of the six faces at the learning stage of the experiment. For the recognition task, the number of correct identifications and their corresponding reaction times were recorded for each subject.

3.1 *Treatment of subjects' descriptions of stimulus faces*

To try to get an idea of the *type* of associations that were made for the six faces originally presented to subjects, subjects' descriptions were classified according to whether or not they mentioned the face's age (either providing an actual age or using an age term), gender, physical attributes (hair, face shape, or specific features), attractiveness, emotional state, or personality traits. These data were analysed by assigning a value of 1 if a category was used, and 0 if it was not. To give an example, the description "a young girl with lovely large eyes who is probably naughty" would obtain a score of 5. This would be made up of 1 for mentioning an age term (young), 1 for gender (girl), 1 for attractiveness (lovely), 1 for mentioning physical attributes (large eyes), and 1 for reference to a personality trait (probably naughty).

3.2 *Summary of subjects' descriptions*

Overall, the length of subjects' descriptions varied considerably. The mean length of descriptions was 11.24 words per face (standard deviation 7.32), but the shortest description was 1 word long, and the longest consisted of 38 words. The incidence of each type of description is illustrated in figure 2. The graph shows the percentage of descriptions that referred to each of the major categories. As can be seen, the most frequent description was a reference to age, which was used for 70% of the faces. Of this 70%, 40% were references to actual chronological age and 46% were age terms (note that 17% included both types of age description). Out of the 61% of descriptions that made reference to the physical properties of a face, 39% made reference to hair, 39% referred to specific features (for example, the eyes, nose, ears), and 18% referred to face shape. (35% of references to physical properties involved more than one of these subcategories.)

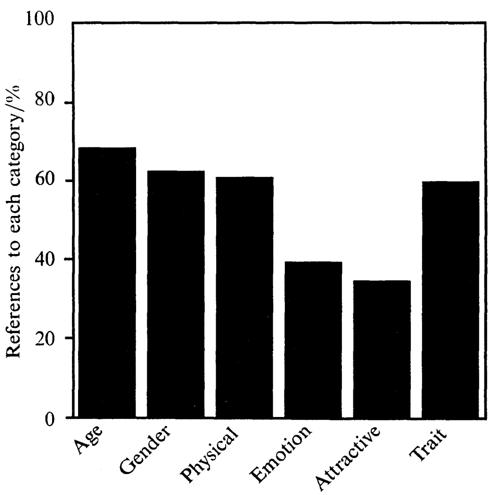

Figure 2. Frequency of descriptions used for unfamiliar faces. The six major types of description (age, gender, physical, emotion, attractive, and trait) are indicated on the horizontal axis. The number of times each type of description was used is indicated by the vertical axis (in percentages).

3.3 *Recognition performance*

3.3.1 *Comparison of the recognition performance for the six sets of faces.* Two one-way independent-measures analyses of variance (ANOVAs) were used to compare the overall recognition performance for the six faces. The analysis revealed that there were no significant differences between the faces used in terms of correct identification ($F_{5,474} = 1.65$, ns) or reaction times ($F_{5,474} = 1.25$, ns) suggesting that the faces were comparable in the ease with which they could be recognised.

3.3.2 *Comparison of male and female recognition performance.* To explore the overall recognition performance for male and female subjects, two ANOVAs were used. These revealed that there were no statistically significant differences between male and female on identifications ($F_{1,78} = 0.44$, ns) or reaction times ($F_{1,78} = 0.00$, ns), suggesting that performance for male and female subjects was comparable.

Since these results suggest that performance for the different faces for male and female subjects did not differ significantly, the data were collapsed across target face and gender of subject (subsequent analyses were performed independently of the face being recognised or the gender of the person in question).

3.3.3 *The relationship between recognition and descriptions of faces.* To explore if there was any relationship between the descriptions given at the encoding stage (both the length and the quality) and subsequent recognition performance, a series of Pearson correlations were performed. Apart from the number of words used, all subjects were given a score out of 6 to indicate the number of correct identifications, and a score for each time a category of description was used.

Analysis of these data revealed that there was no relationship between the length of the descriptions and subsequent recognition performance ($r_{79} = 0.02$, ns). In short, recognition of a face did not appear to be influenced by the quantity of words used to describe it. Trying to determine if there was a relationship between the *type* of descriptions and subsequent recognition was very difficult, simply because the comparison-group numbers were (in some cases) very small. Nevertheless, there was a tendency for those subjects who made explicit references to the shape and the attractiveness of a face to recognise proportionately more faces than those who did not make such references. This relationship was found to be statistically significant (face shape versus correct identifications: $r_{79} = 0.24$, $p < 0.05$; attractiveness versus correct identifications: $r_{79} = 0.25$, $p < 0.05$).

One final point of interest was to determine if there was a relationship between the use of age descriptions and recognition rates for faces of a different age. To investigate this issue, subjects in the 'younger' and 'older' recognition conditions were categorised by the number of age descriptions that they gave and the number of correct identifications that they made. Overall, there did appear to be a tendency for subjects who gave explicit references to age to recognise proportionately *fewer* faces than those who did not, although this difference was only marginally statistically significant $r_{39} = -0.23$, $p < 0.10$). A discussion of the issues involved in exploring such relationships is deferred until section 4.

3.3.4 *Number of correct identifications.* The highest number of correct identifications was for the experimental condition 'same image', which produced nearly ceiling performance (97.5%). For the subjects whose task was to recognise an older version of the face than they had learnt, the recognition rate dropped to 69.2%. Broadly similar performance was obtained for those faces that were of the same age (at 67.5% correct). The poorest recognition performance was for the experimental condition which involved younger faces than had been learnt, with only 49.2% of faces being correctly identified.

An ANOVA with four levels of condition confirmed that the difference between experimental conditions was significant ($F_{3,476} = 26.81$, $p < 0.001$). Newman–Keuls a posteriori tests revealed that there were significant differences (at the $p < 0.01$ level) between all conditions except between the 'older' and 'same age' conditions.

3.3.5 *Reaction times.* The mean reaction times for correct recognition judgments are shown in figure 3. It can be seen that reaction times were fastest for the 'same image' conditions (784 ms). The 'older', 'same-age', and 'younger' conditions produced much slower reaction times (1434 ms, 1578 ms, and 1588 ms, respectively). A one-way independent-measures ANOVA comparing the four experimental conditions revealed that the difference between experimental conditions was statistically significant ($F_{3,472} = 4.40$, $p < 0.005$). Newman–Keuls a posteriori tests showed that the 'same-image' condition produced significantly faster reaction times than all other conditions ($p < 0.01$); there were no significant differences between the 'younger', 'older', and 'same-age' conditions.

In summary, the time taken to recognise older and younger versions of learnt faces was little different from the time taken to recognise a different view of a previously encountered face. As the faces that were younger, older, and the same age all had different facial expressions and/or pose from the learnt face, it appears that the additional age-related differences in the younger and older faces had *no* detrimental effect

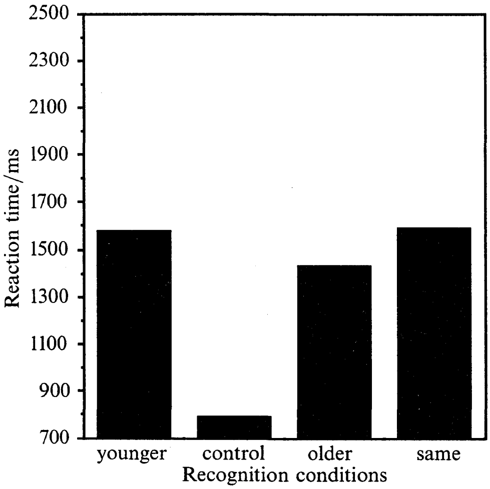

Figure 3. Mean reaction time to recognise the different versions of a previously learnt face for the four recognition conditions.

on the time taken to recognise them.

4 Discussion

This experiment was designed to explore the role of information about age in face-processing. This problem was approached from two directions. The first was to try to determine the type of associations that are made for previously unseen faces at the encoding stage. A second approach to this problem was from the perspective of the facial representation, by trying to determine how well people can or can not cope with age-related changes.

First, consider the role of age from the perspective of encoding. As a means of establishing the types of associations made for previously unfamiliar faces, participants were asked to describe each face in their own words. The results suggest that the age of a face is very important since references to age were made more than references to any other attribute (70% of descriptions contained some reference to the perceived age of the face). While this suggests that information about age may be used to facilitate the encoding of a new face, there are some general difficulties with this methodology. Put rather simply, there is always the possibility that any descriptions given for a particular face were not used to encode it or that the dimensions that were used at encoding were not reported for whatever reason.[2] To try to clarify this issue it was hoped that it might be possible to compare recognition performance for those subjects who referred to age and those who did not. For subjects given the task of recognising faces in a different age version from that originally seen, there was a tendency for those who used an age description to recognise proportionally *fewer* younger or older versions that those subjects who did not. However, any overall conclusions about the relationship between the descriptive category used at encoding and subsequent recognition rates must remain tentative because of the different (and in some cases very small) cell sizes. A full analysis along these lines would require a much larger study.

Despite these difficulties, it is important to note that the types of information highlighted in the present study involving descriptions (see figure 2) are remarkably similar to those identified by other researchers who have used completely different methodologies. For example, Shepherd et al (1981) concluded after reviewing a large number of research findings involving discrimination tasks that age is one of only three major dimensions [age, hair, and face shape[3]] that seem to account for all perceived variation between faces. More recently, Johnston et al (1997a, 1997b) have explored the dimensions that are used to encode faces by using face-categorisation tasks. While their results are complex and discussed in terms of distinctiveness, they come to broadly similar conclusions to Shepherd et al with respect to the importance of age. Although their work is more speculative in nature, Benson (1995), Johnston and Ellis (1995), and O'Toole et al (1995) all suggest that determining information about age may be necessary for efficient encoding of faces. Since there is such consistency regarding the role of age, there is a strong case to suggest that information about age is used to encode a face.

The role of age was also explored from the perspective of a facial representation, by comparing recognition performance for the same-age faces with recognition performance for different-aged faces (relative to presentation). For the same-age faces, the highest number of correct identifications was produced by subjects whose task was to identify *exactly* the same face as previously encoded; in this condition, performance was almost at ceiling (97.5% correct identifications). As this task is effectively picture recognition rather than face recognition per se (Bruce 1988), these results were expected and are consistent with early studies that also involved the same face at presentation and test (see Ellis 1975 for a review). Faces that were the same age but had a different pose/expression produced nearly 70% correct identifications. These results are also consistent with previous research (eg Bruce 1982) in which changes in angle of view and expression produced a reduction in correct identifications compared with when exactly the same face was used at presentation and test.

The effects of viewing faces at test which differed in age from those originally presented differed according to the direction of the age difference at test. A rather surprising finding was that those subjects who saw faces at test which were older than the ones originally inspected produced similar recognition performance to those subjects who saw the same-age version (69% and 67.5% correct, respectively). In contrast, recognition performance was significantly impaired for those subjects who were tested with faces that were younger than those first seen (49% correct identifications). Although in

[2] For example, it is possible that the faces of children (which were used in the present study) may be categorised in age terms more than those faces of other ages. From a different perspective, there may be a distinction between the way facial information is subjectively thought of (and in this particular case given as a description) and how the visual system may use that information: in short, some dimensions may not be easily accessible to verbal labels.

[3] As noted previously, the shape of the face can also be taken as a reference to age since a number of researchers (eg Pittenger et al 1979) have demonstrated that face shape is a primary perceptual cue to the age of a younger (premature) face.

terms of chronological age the younger and older faces were equally dissimilar from the faces originally viewed, subjects appeared to be able to cope with older-aged versions of faces better than with younger-aged versions. Although this difference was statistically significant only for the accuracy data, there was some evidence of a similar pattern in the reaction-time data, with subjects reacting more slowly to the 'younger' condition than to the 'same-age' and 'same-image' conditions.

The asymmetry in the present results may be explained by a consideration of the rate of change. Although the *chronological* ages of the younger and older versions were symmetrically arranged around the encoded version, the younger faces might have been perceived as significantly more different *developmentally* from the encoded versions than were the older faces. The relatively poor recognition performance for younger faces (which also had different structural properties from the encoded face) may emphasise the difficulty inherent in using years as a means of understanding or exploring age invariance without a consideration of the age of the face itself [for example, Enlow (1982) has pointed out that the rate and type of change depends upon the age of the face itself]. For example, growth-related changes during the first two years of life are not equivalent to the changes occurring during the following two years. Given the non-linearity of the changes that occur through ageing, it is therefore probably the case that the more a face is perceived as deviating from the one that was originally learnt, the more difficulties this presents for the process of recognition.

However, trying to reconcile the role of age from the perspective of encoding (by categorising the descriptions) with recognition performance (as a measure of age invariance) is difficult since the results can be seen as contradictory. For example, if information about age is used in the same way for encoding and for the purposes of recognition, then recognition of the same individual despite age-induced changes would *not* be possible. As already noted, the results suggest that this is not the case. Indeed, performance for those subjects whose task it was to recognise older versions of previously learnt faces was indistinguishable from those subjects whose task it was to recognise same-age versions. While previous research (see Bruce 1988 for a review) has tended to emphasise facial representations as being invariant of the more transient type of changes that occur to faces (those that leave the underlying structure of the face and head intact), age-related changes are arguably very different. For example, the age range of faces used in the present study was premature with respect to growth and therefore the changes between presentation and test include changes to the shape of the head/face.

Although there is always the possibility that observers were 'blind' to the age-related changes, this explanation is unlikely since previous research has demonstrated that even small age-related changes are discernible (see George and Hole 1995 for sensitivity to changes from the life-span perspective; see Mark et al 1988 for a review of sensitivity to changes that occur during the period of growth). In addition, simply because younger and older age versions of these faces were not recognised equally well it can be assumed that a new facial representation contains some information about age. Nevertheless, trying to determine the format of age information on the basis of recognition performance alone is difficult given the ambiguity of the results. One explanation might be that age information is utilised in a broad way within a representation, perhaps from some kind of prototypical age face. Indeed this is something along the lines of what Johnston et al (1997a) have demonstrated on the basis of a face-classification task. Although they only used two broad age categories for male and female faces (male child, female child, male adult, and female adult), they suggested that these four 'types' of face are differentially encoded relative to a norm or prototypical face for each. Although this is speculation, it may be the case that there are more age categories than Johnston et al (1997a) used, which if valid may provide a framework for exploring the 'broad-age' hypothesis further.

From a more general perspective, simply because a large number of the different-age faces were recognised, this in itself demonstrates that it is possible to recognise a face that has changed structurally since it was last seen: in other words, because the growth-related change associated with getting older appeared to present no (additional) difficulties for the process of recognition, it can be concluded that successful recognition is not restricted by the underlying structure of the face/head at the time of encoding. It is therefore possible to eliminate at least some of the possible theories proposed in section 1 with regard to the role of age within a facial memory. First, the results do not support the multiple-representation theory proposed by Ellis (1988). Although this theory is plausible in the case of individuals whom we have known for some time, it implies that a different-aged version of a relatively unfamiliar face should not be recognisable, as no representation could exist for that face. The results of the present experiment clearly do not support this prediction.

The results also do not give much support to the theory that the representation of a face is completely 'ageless'. This theory would require faces to be age transformed at encoding, into some kind of ageless form, before any matching operation took place, thus placing all the recognition burden on initially extracting an age-invariant memory. If this were the case we might have expected similar recognition performance for all the experimental conditions (similar reaction times would be expected since all faces currently in view would be age transformed and similar percentage correct since matching faces in view with faces in memory would not involve information about age), which as already noted we did not find. However, the possibility remains that there may be an age-transformation process and that either it occurs so rapidly that its effects do not show up with the present methodology, or that the degree of agelessness is constrained.

To conclude, the associations obtained at encoding are consistent with previous research, which collectively demonstrates that information about age is a very important facial attribute, which in turn implies that information about age might be an intrinsic part of a facial representation. However, from the perspective of recognition, although the findings are based upon a limited number of faces covering a limited age range, the most important finding is that the process of recognition is not constrained by specific information about age at the time of encoding: in other words, successful recognition does not require an exact match of age characteristics. One explanation could be that information about age is broadly defined within memory—something like 'young child' or 'older child'. An alternative explanation is that information about age is more specific to the time of encoding, but that the process of recognition utilises an age-transforming operation that is to a certain extent flexible, depending upon the amount of perceived change since the last encounter. As it stands, it is probably impossible to distinguish between these two explanations further, although both indicate that the process of recognition is invariant of age to a certain extent. It is worth noting that the degree of age invariance found in the present study was found even when the representation was derived from an 11 s exposure to a static photographic image. Since the faces used in this study represented changes that occur during growth, such age invariance demonstrates that an exact match in the underlying physical properties is not necessary for successful recognition.

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